Next Generation Space Telescope (NGST)

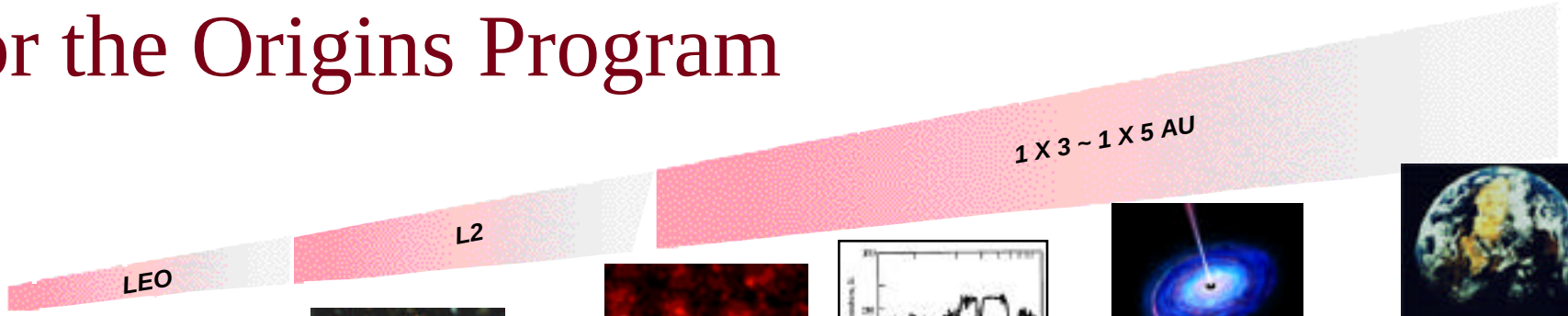
Presented by

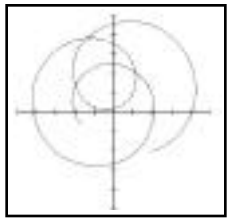
Bernie Seery
Project Manager

Outline

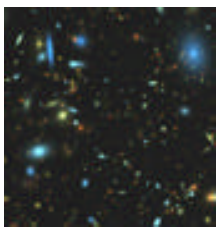
- Science with NGST
- The Challenges
- The Concepts
- Enabling Technologies
- Technology Testbeds & Validation Flights
- Programmatic
- Summary

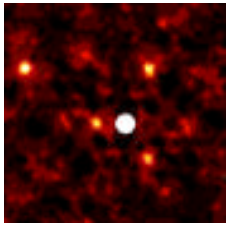
Large Space Telescopes for the Origins Program

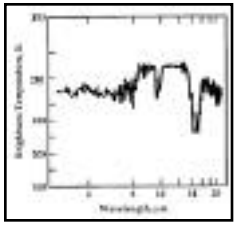


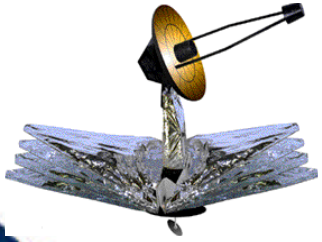


Space Interferometry Mission

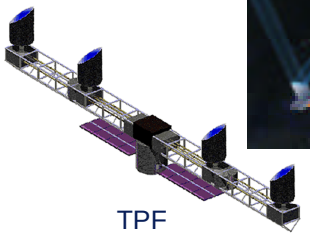






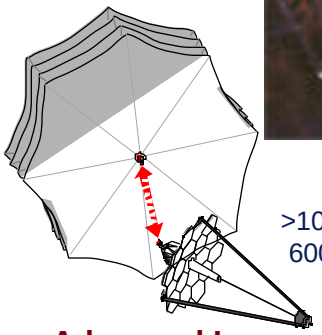


NGST 8 m Aperture



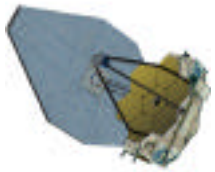
TPF Physical Baseline Option

TPF Virtual Baseline Option



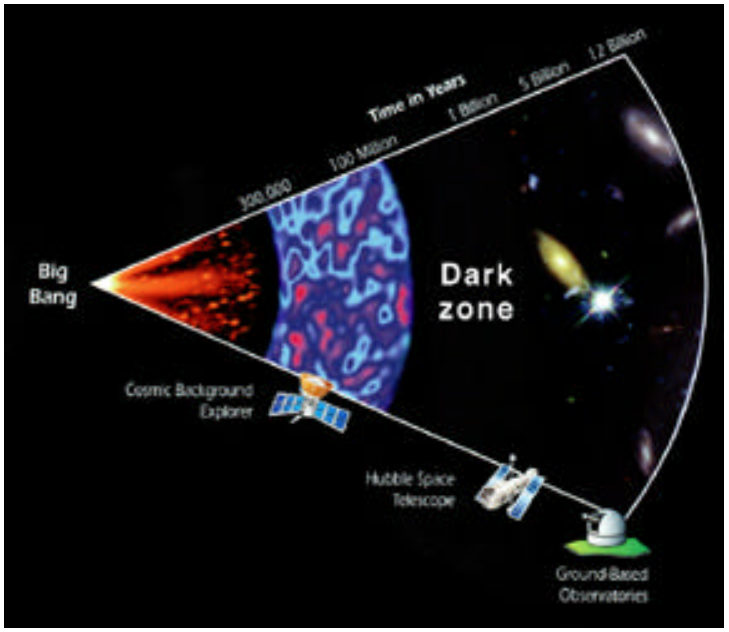
Advanced Large Aperture Architecture >20 m

Terrestrial Planet Imager
>1000 m^2 Total Aperture
6000 km Baseline (IR I)



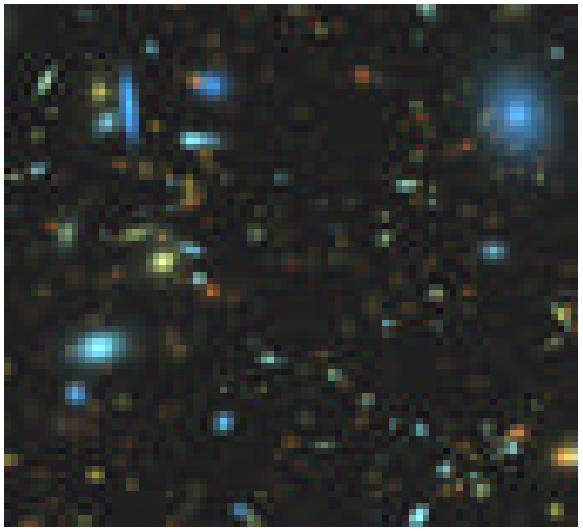
NGST Deployable Active Optics Pathfinder

The *Hubble Deep Field (HDF)* Points to the Origins of Stars and Galaxies and the Future of *NGST*



- *Faint galaxies seen to ~ 12 billion light years approx. 1 - 2 billion years after Big Bang*
- *To view the Dark Zone, NGST needs HST resolution – galaxies/early structures are small!*

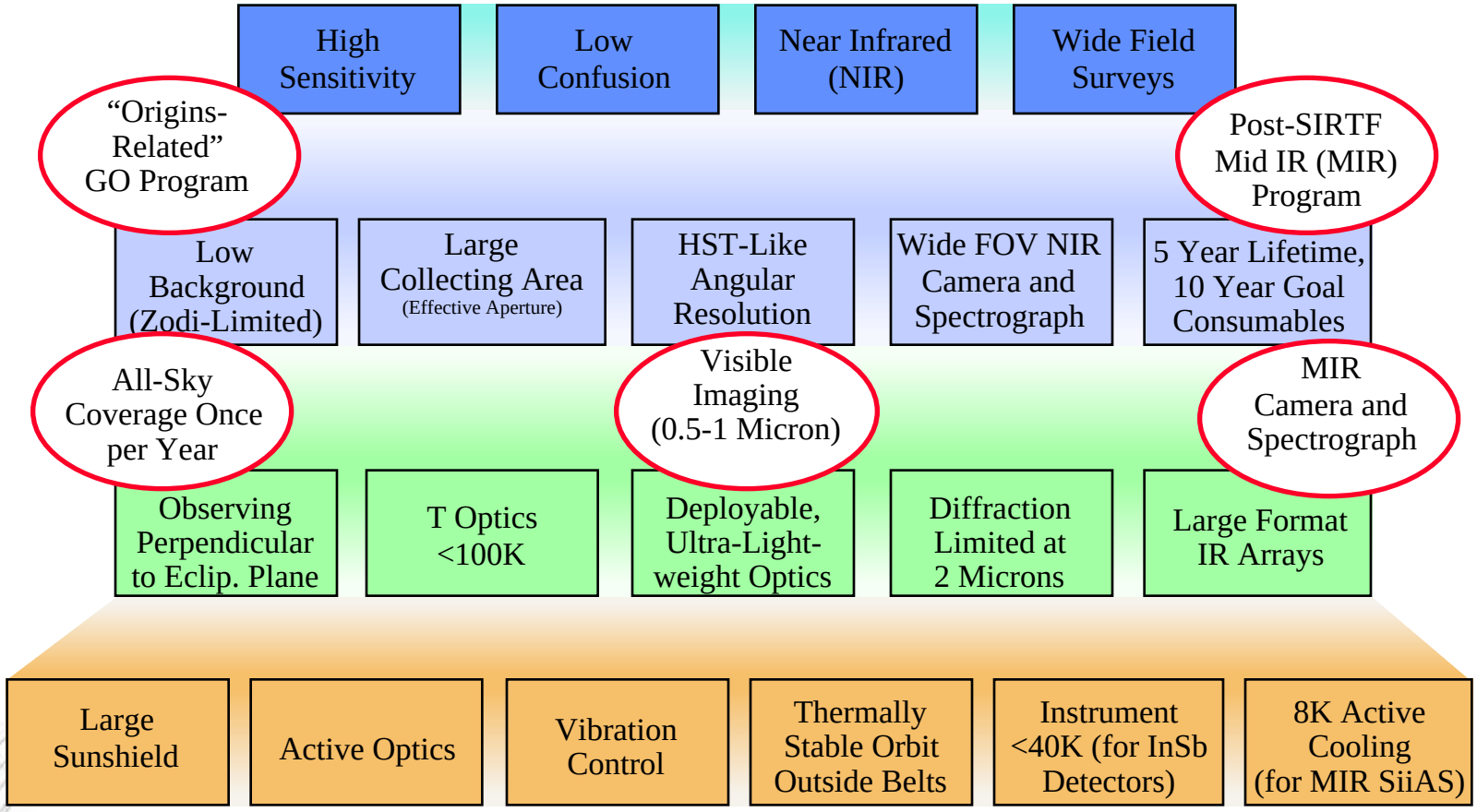
- *HDF is deepest image of the sky*
- *Keck Telescope confirms high redshifts.*



NGST will have greater sensitivity than HST and can see further back in time.

Next Generation Space Telescope
NGST
A NASA Origins Mission

Science Drivers and Requirements Flowdown



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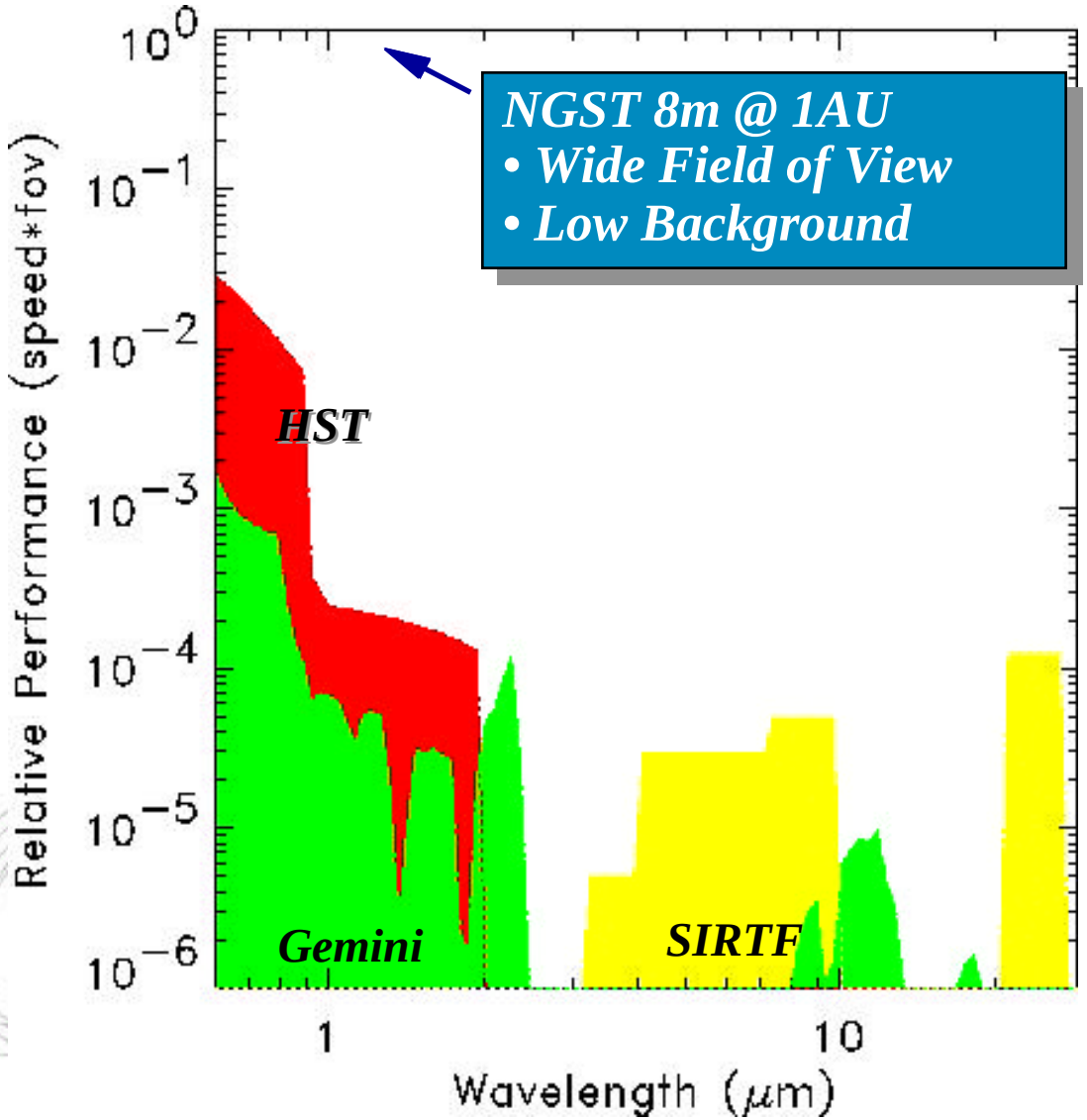
NGST Provides > 10^3 Speed Improvements From 0.5-30 µm Over Other Planned Facilities



Visible Science

- Kuiper Belt Survey
- Planet Searches
- Stellar Pops in the Galaxy & Local Group of Galaxies

MIR Science

- Protoplanets & protostellar obj.
- Dust enshrouded galactic nuclei & star formation
- Interstellar Media studies.
- Solar System atmospheres

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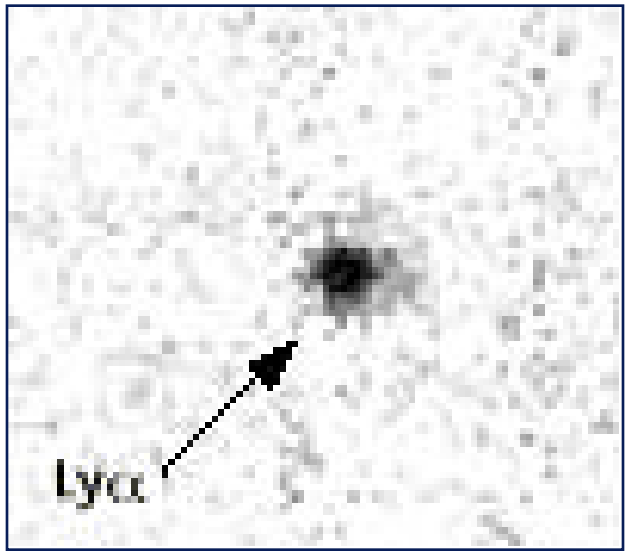
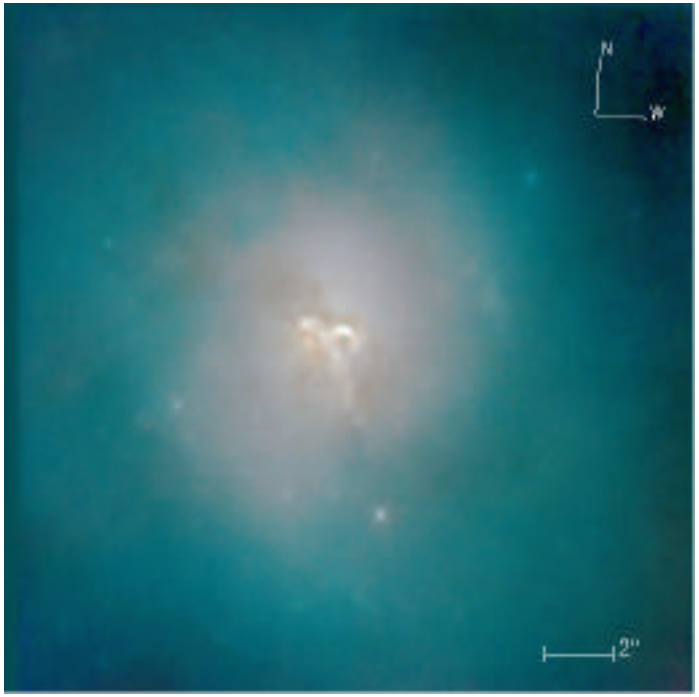
DRM Science Programs

- DRM Divided into “Core” and “Extended” Components
  (Core ≡ HST & Beyond goals, Extended ≡ Everything Else!)
  - Early Formation of Stars and Galaxies (Core)
  - Distant Supernovae (Core)
  - Structure and Dynamics of Galaxies at $z \geq 2$ (Core)
  - Gravitational Lenses (Dark Matter studies)
  - Stellar Populations in Local Group out to Virgo Cluster
  - Kuiper Belt Objects at greater than 40 AU
  - Protostellar Systems
  - Plus:
    - Gaps and disks in protostellar regions
    - Brown Dwarfs and White Dwarfs
    - Active Galactic Nuclei (e.g., quasars)

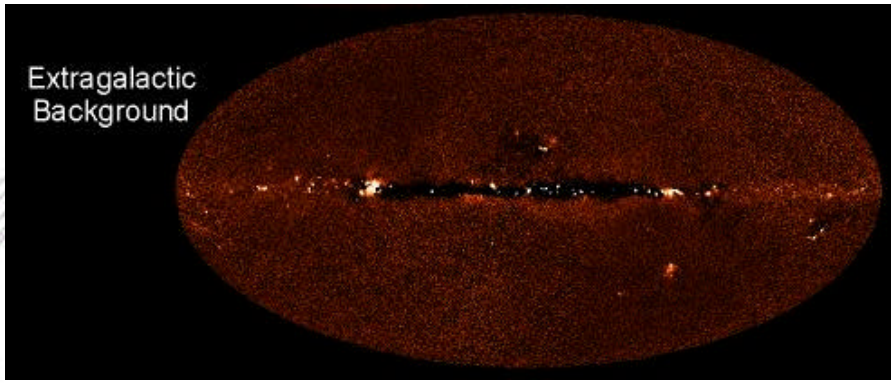
Recent Results Indicate the Importance of Infrared Astronomy



Red-shifted Lyman-alpha image of galaxy at Z=5.34 observed by Keck



NICMOS shows IR penetrates dust into cores of active galaxies (image of Arp 220)



COBE/DIRBE measured Far-IR cosmic background - shows early universe has dusty galaxies

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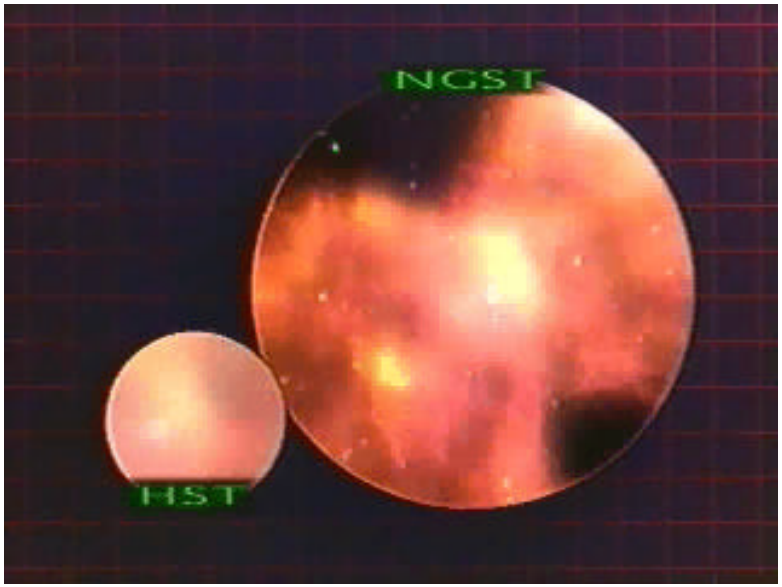
The Challenge

- In the spirit of providing the scientific community with "order of magnitude" performance improvement at an "affordable" cost…
  - Provide a worthy successor to HST with the following features:
    - 10 times the collecting area of HST
    - <25% of the launch mass of HST
    - 1/10th of the lifecycle cost of HST in real year dollars



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Science and Engineering Goals

Parameter	HST	NGST Science Floor	NGST Stretch Goals
Wavelength Range	Ly a - 2 µm	Near Infrared	0.5 - 30 µm
Angular Resolution	Diffraction-Limited at 0.55 µm	Diffraction-limited at 2 µm	Diffraction-limited at 0.5 µm
Aperture Diameter	2.4m	> 4m	> 8m
Sensitivity	Instrument-Limited (NICMOS)	Zodi-limited at 1 AU	Exo-Zodi background-limited
Lifetime	15 years	> 5 years	10 years
Instruments	WFPC2, STIS, NICMOS, FOC, FGS	Wide Field Camera / Spectrometer	Add visible, MIR Camera / Spectrometer and Coronagraph

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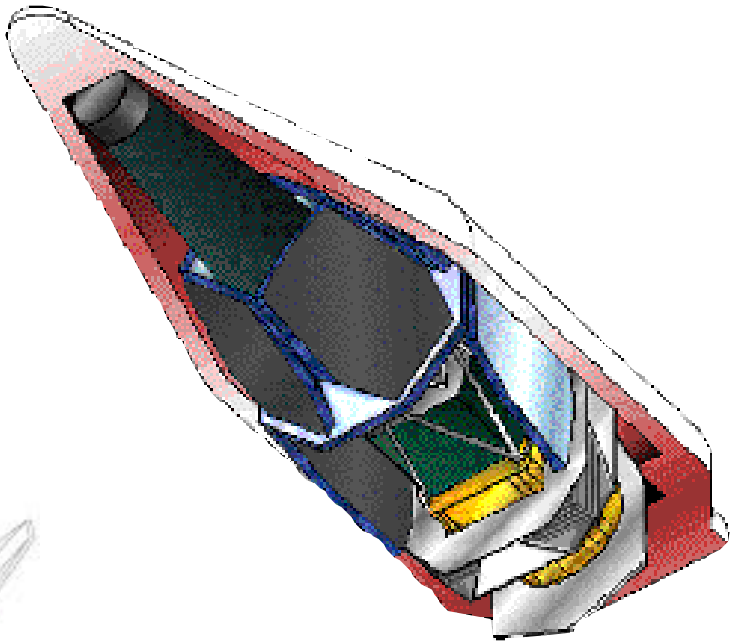
“Yardstick” Reference Concept



Launch Configuration

Deployed Configuration

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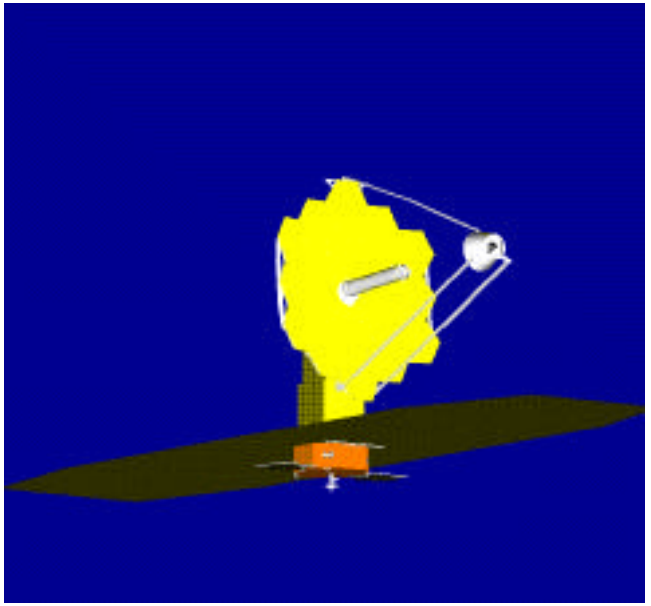
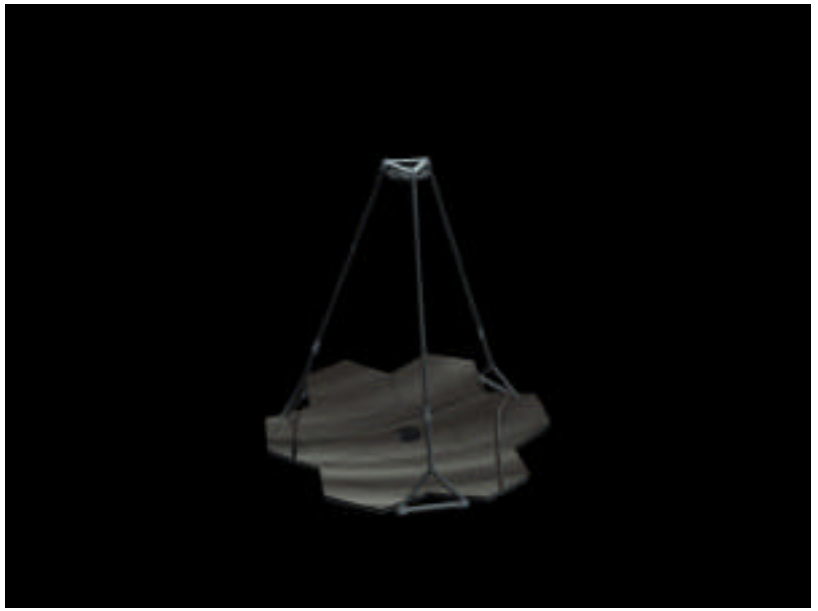
Current Contractors' Concepts

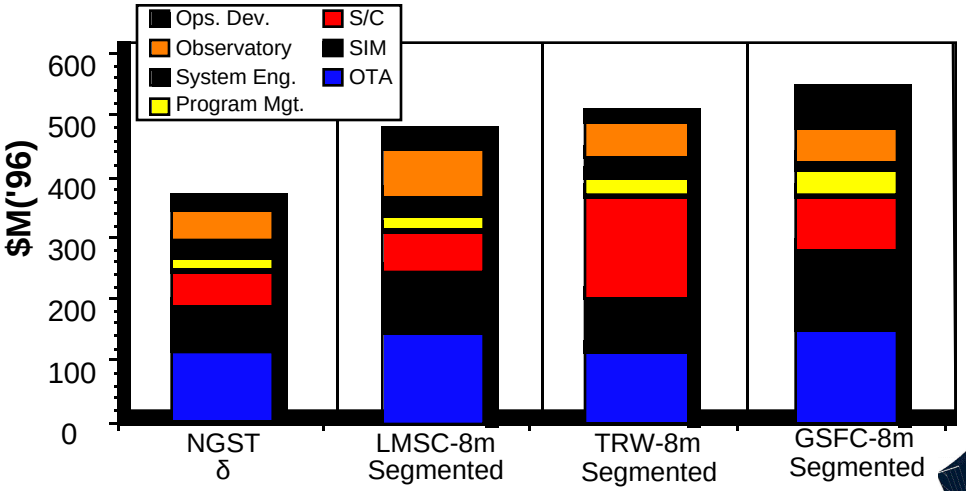


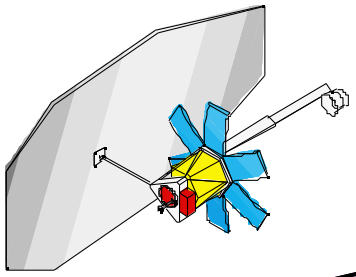
Ball Aerospace

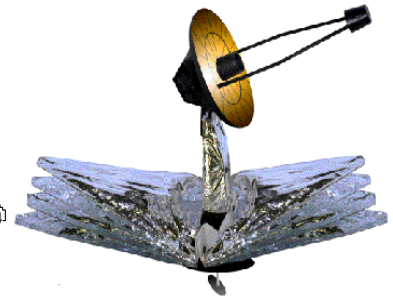


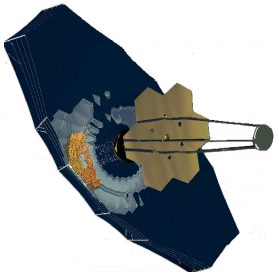
TRW

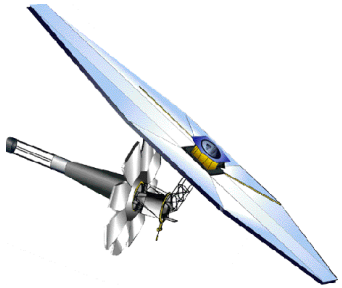
Concept Suite Spans the Requirements Phase Space











- > 12 m²
- Near Infrared (Dressler)
- Deployable 8m aperture
- 0.5 - 10 µm
- 50 m²
- Camera-spectrometer
- Exo-Zodiacal Background Limited
- D.L. - 0.5 µm
- l = 0.5 - 30 µm
- Coronagraph
-

Science Floor **Stretch Goals**

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The NGST Challenge Is to Use New Technology to Make the Mission Affordable

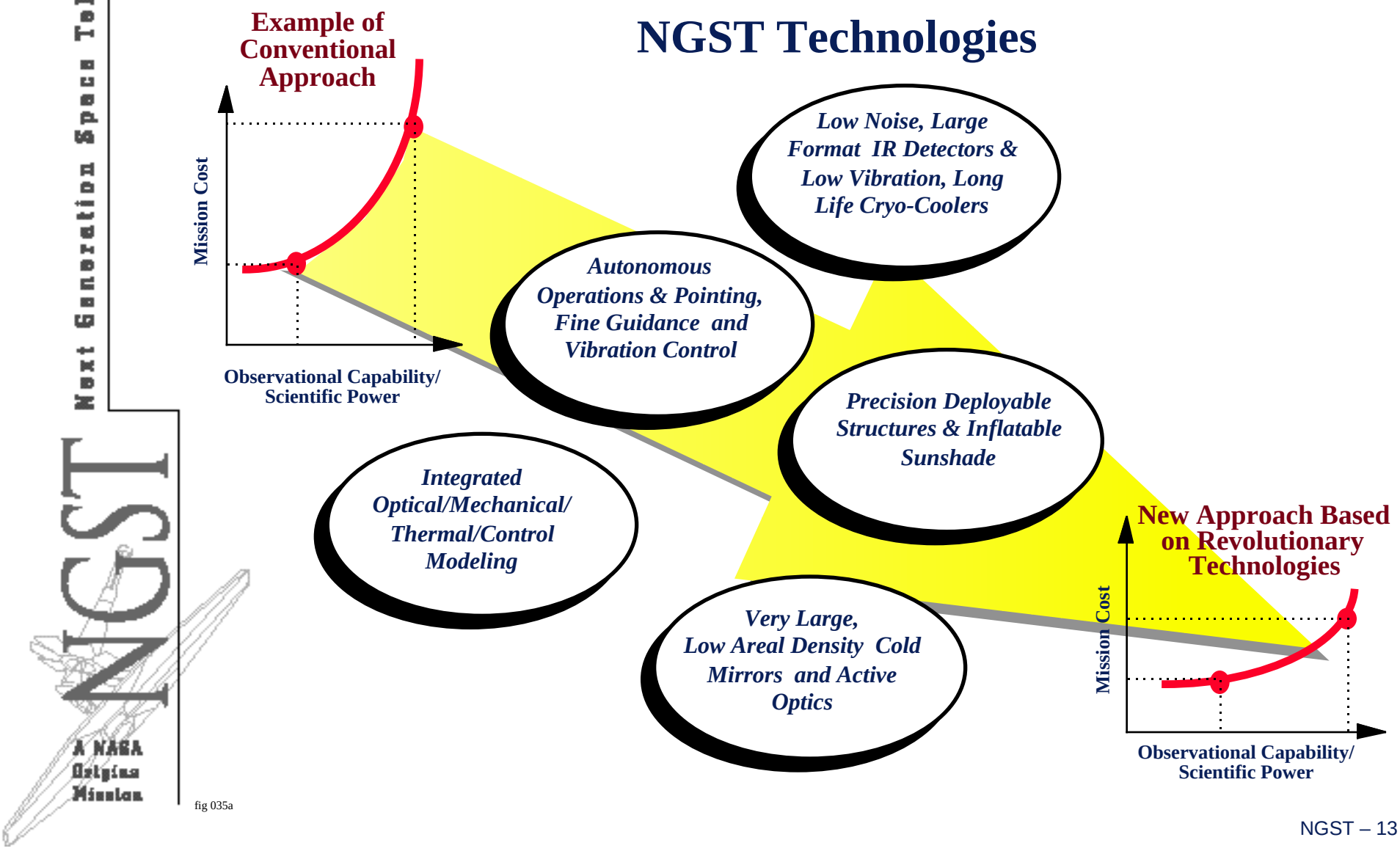

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fig 035a

Key NGST Technology Products/Partners

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Large, Lightweight Cryogenic Primary Mirror

U of Arizona Team
COI Team
Ball/Tinsley
IABG/BDM
MSFC

Large Format Low Noise IR Detectors

U of Rochester
Cornell
SBRC
Rockwell
Ball
ARC

Cryogenic Actuators

Energen, Xinetics
American Superconductor
A.E. Hatheway
Burleigh Instruments
LaRC, JPL

Lightweight Deployed Sunshade

ILC Dover
L'Garde
JPL

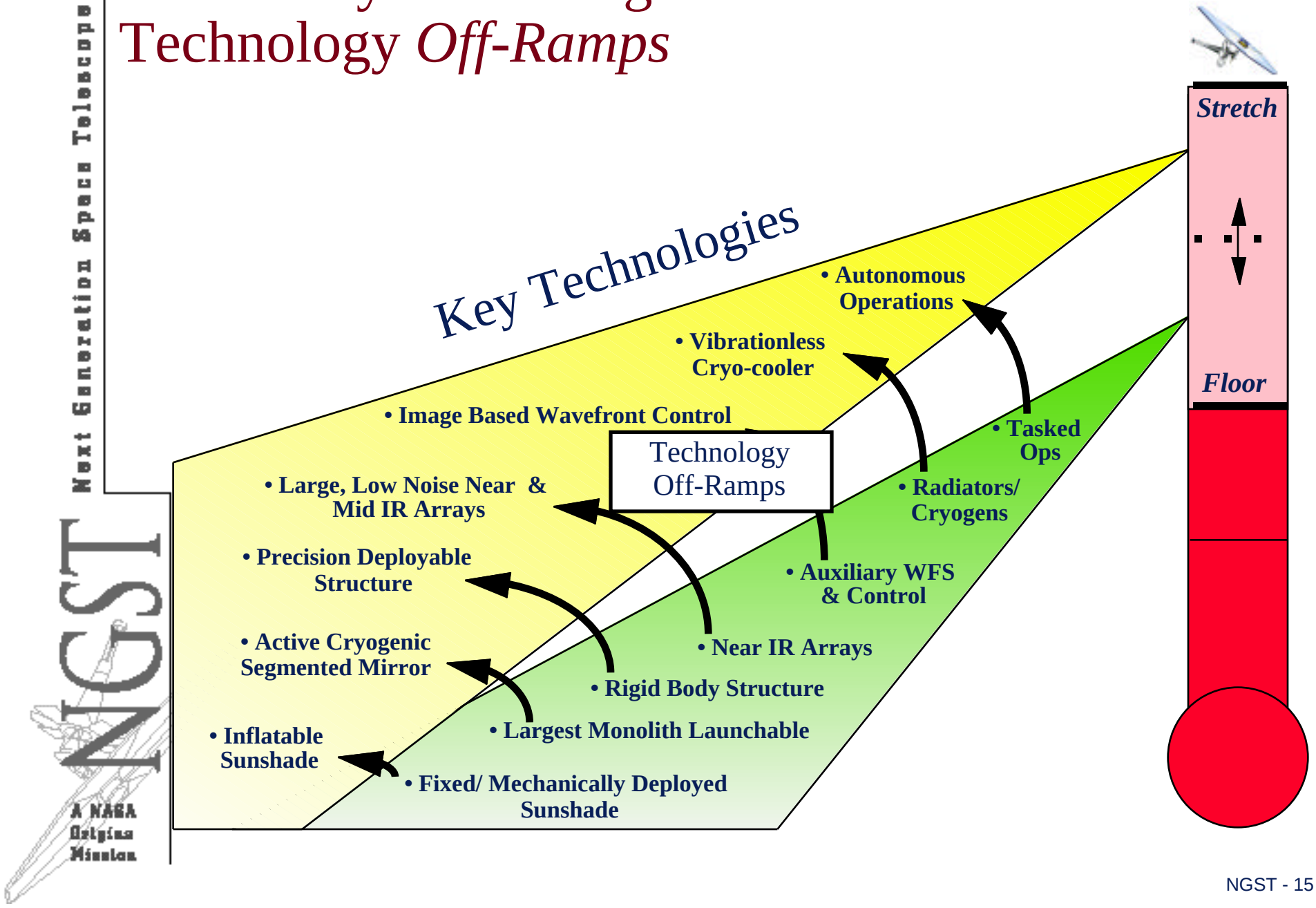
Precision Deployable Structures

TRW
Ball/U of Colorado

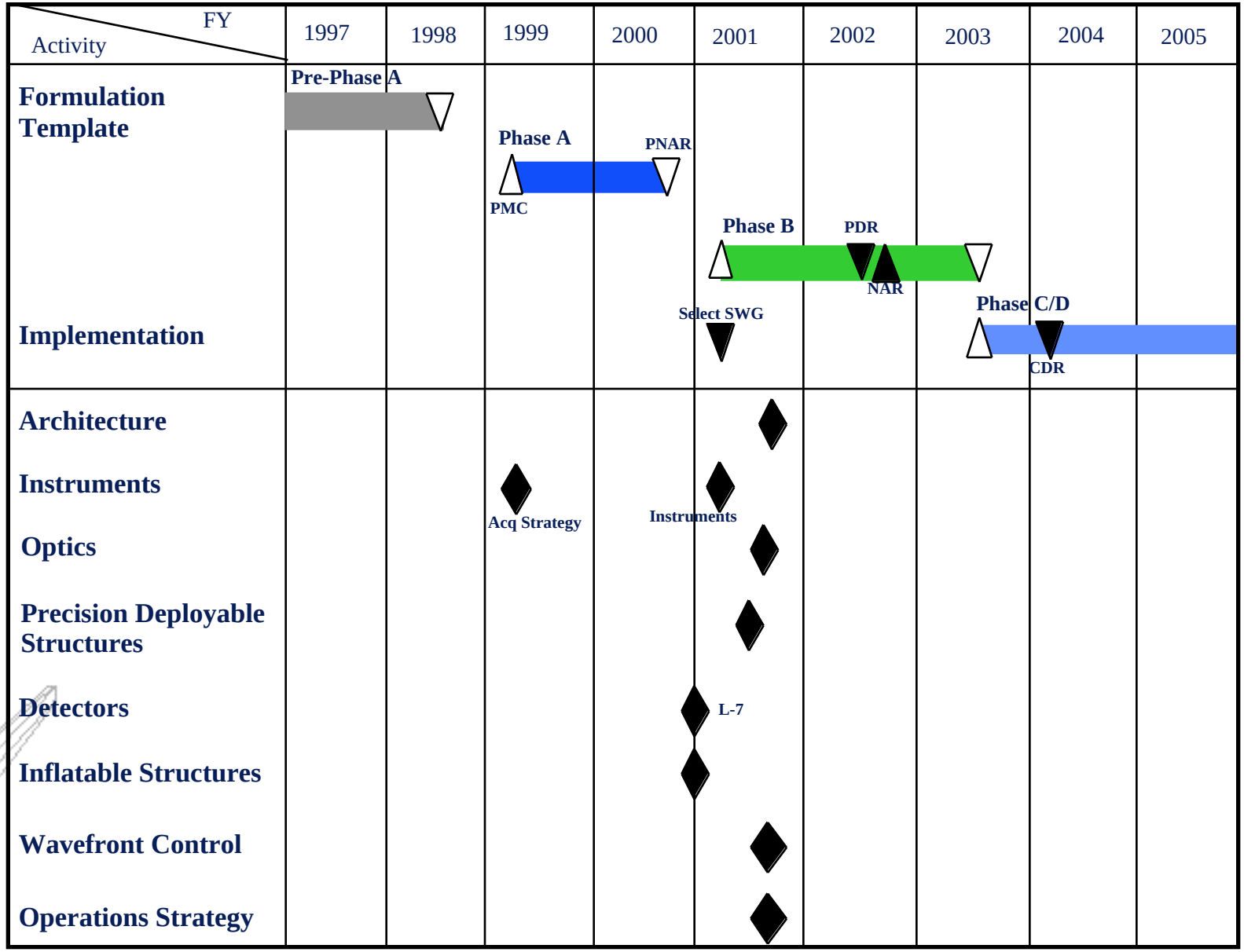
Cryogenic Deformable Mirror

Xinetics
American Superconductor
MSFC,LaRC

NGST Key Technologies and Technology *Off-Ramps*



Decision Milestones



Advanced Concepts for Imagers and Spectrometers

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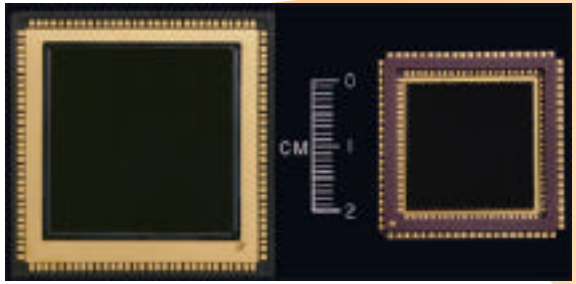
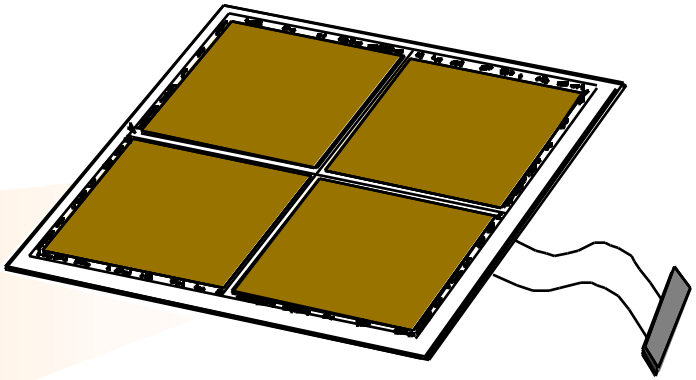
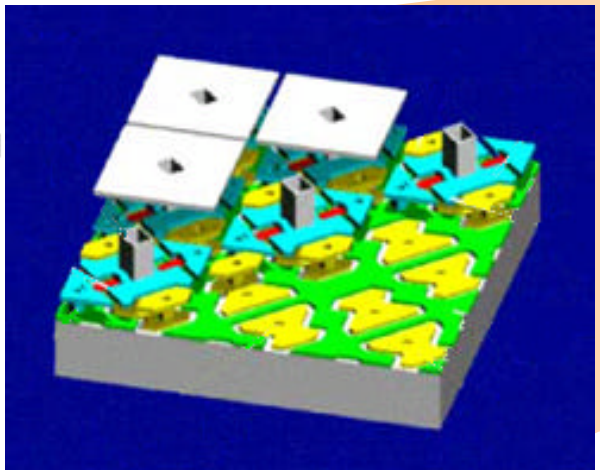
Large Format, Low Noise Focal Planes

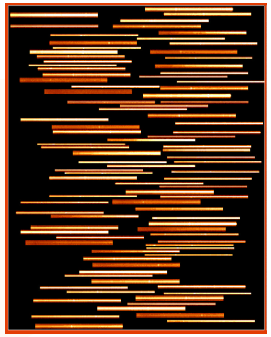




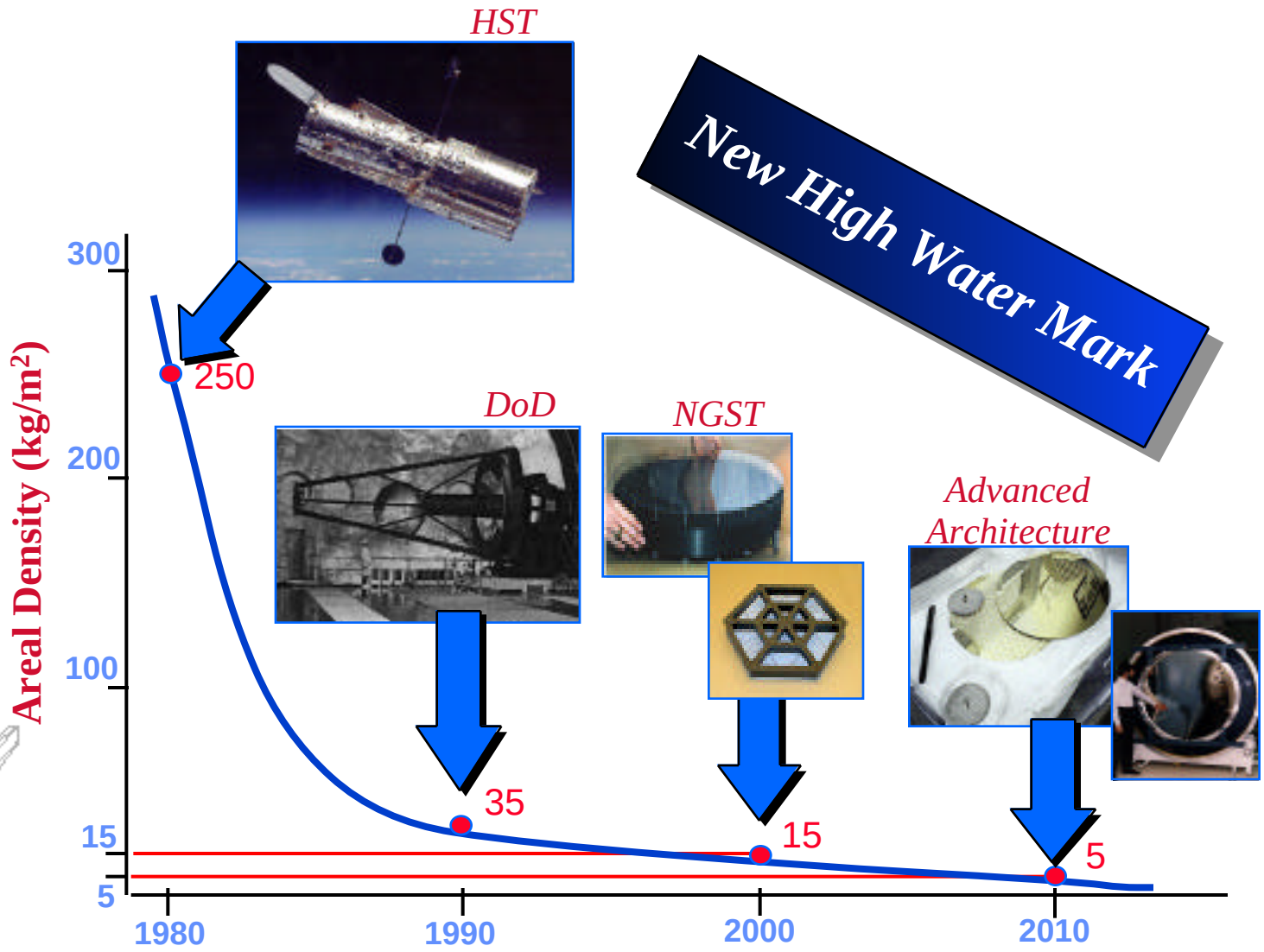
Scale up to 2k x 2k and mosaic

MEMS Concept for Multi-Object Spectroscopy



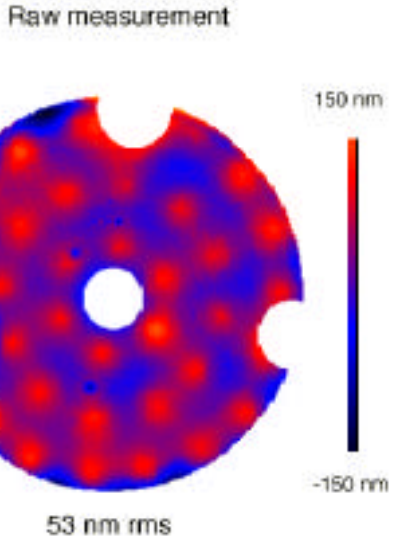


Areal Density

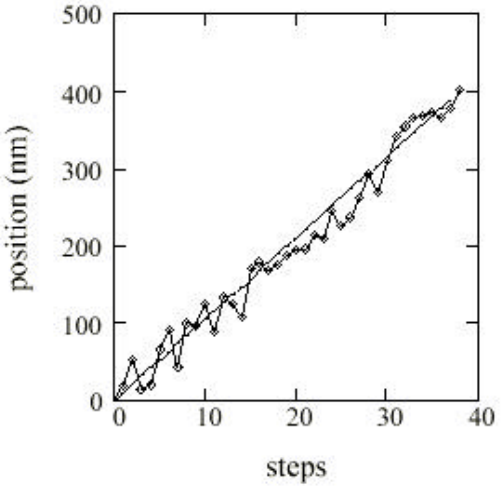


Enabling Optical Technology – *Early Results*

U of A 53-cm Prototype

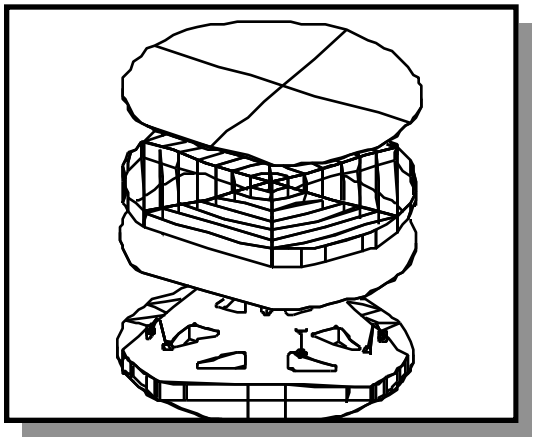


Thermotrex Cryogenic Actuator

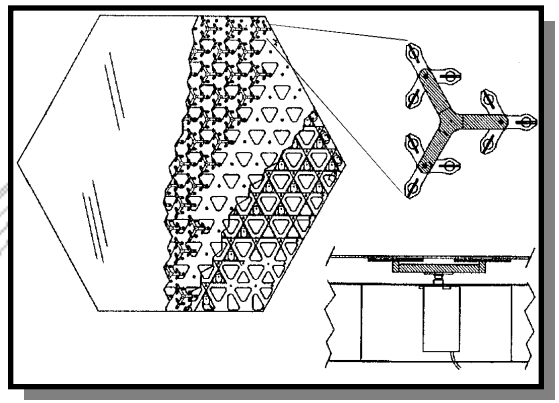


Achieved 25 nm resolution at 77K

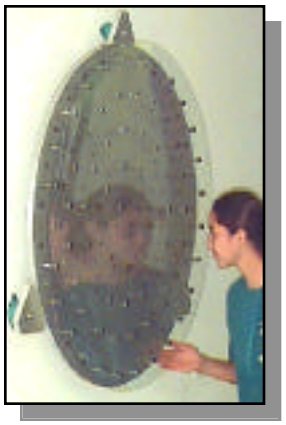
2 Meter-Class Lightweight Cryogenic Mirror Technology



- ***COI Mirror***
  - Zerodur facesheet
  - Composite support structure
  - Invar flexure mounts
  - Tip/Tilt/Piston actuators + ROC correction actuator
  - *14.6kg/m^2 (inc. wires)*

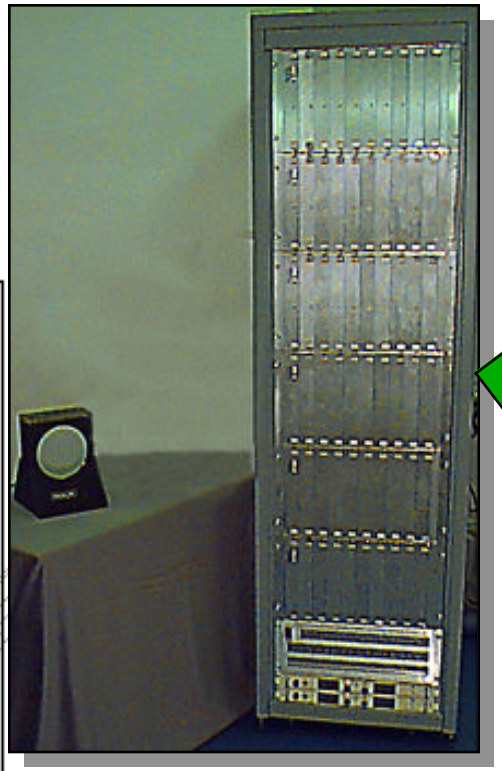


- ***University of Arizona Mirror***
  - Borosilicate glass membrane
  - Composite support structure
  - 50 figure control actuators/m^2 + load spreaders and cabling
  - Tip/Tilt/Piston actuators
  - Launch restraints
  - *13.7kg/m^2 (inc. wires)*



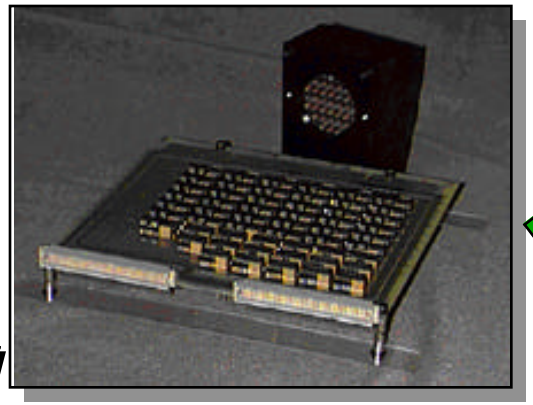
Compact, Low Mass and Power Deformable Mirror Driver Technology

Commercial DM & Drive Electronics



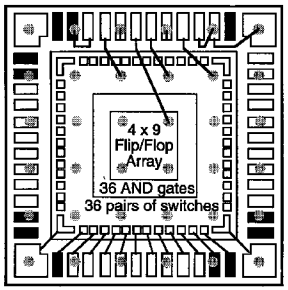
Today

Commercial DM & Prototype Multiplexed Driver Board (Xinetics)



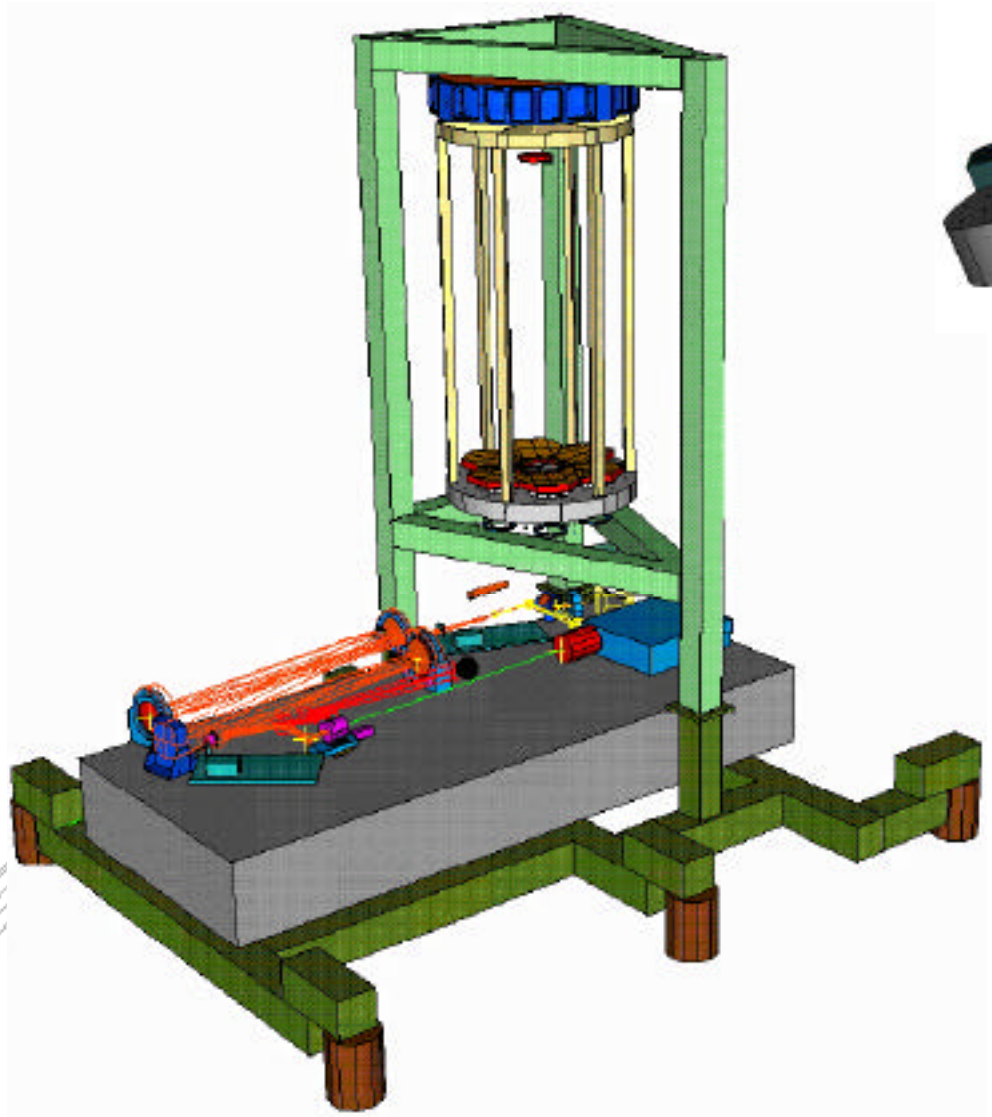
Tomorrow

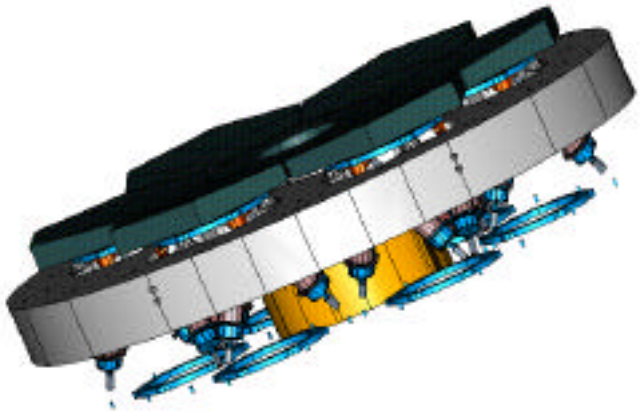
Driver on a Chip



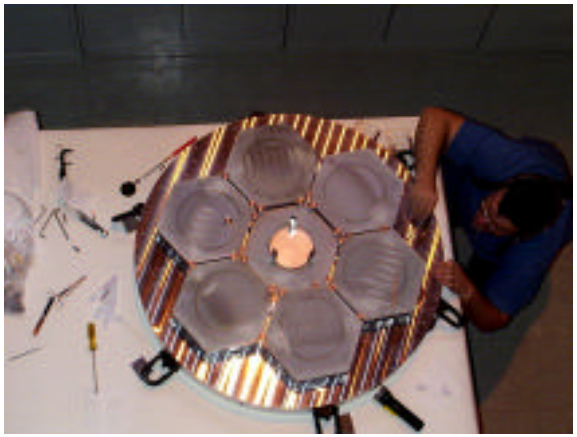
NGST

Developmental Cryogenic Active Telescope Testbed (DCATT)



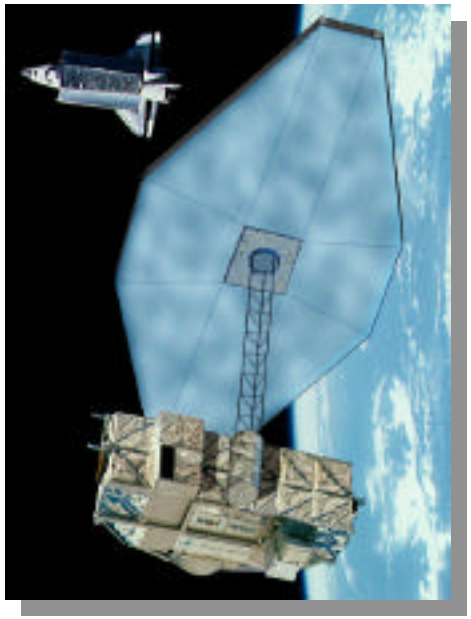


- Segmented active primary mirror
- 6 DOF control of each segment
- Nickel-plated Al



1 Meter Primary Mirror Assembly

Pathfinder – Inflatable Sunshield in Space Experiment



100 m² Half-Scale Sunshield

Stowed
(0.3 m Square)

Vertical
Deployment

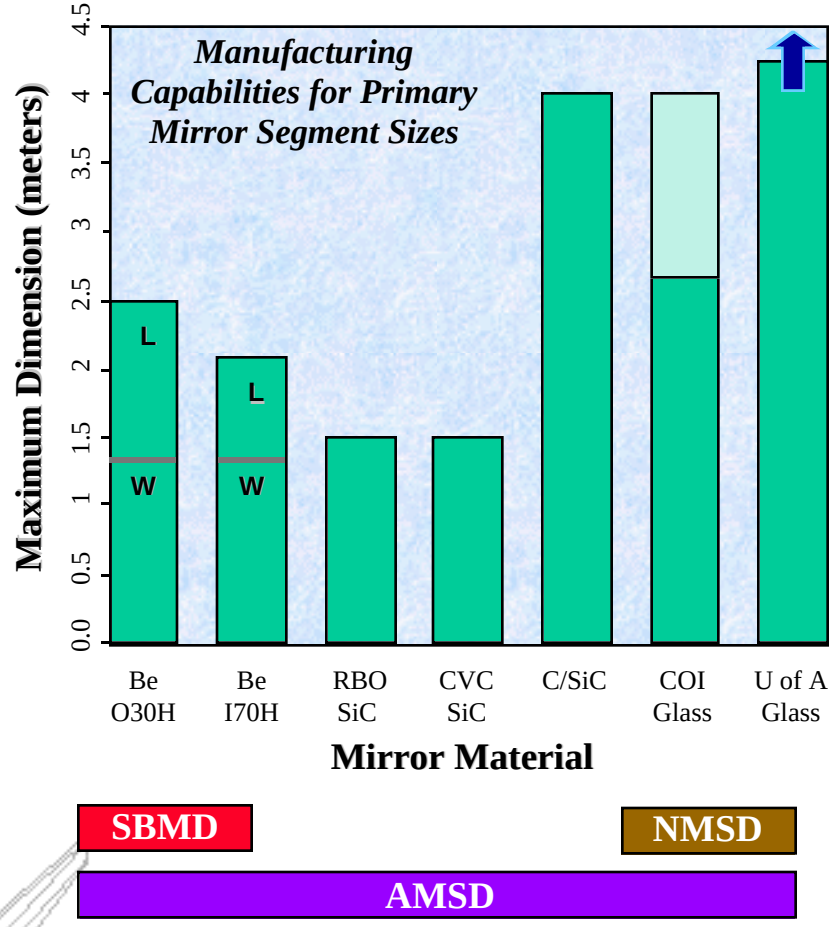
Vertical
Deployment
Complete

Horizontal
Deployment

Deployment
Complete
(*2 X 1.25 m*)

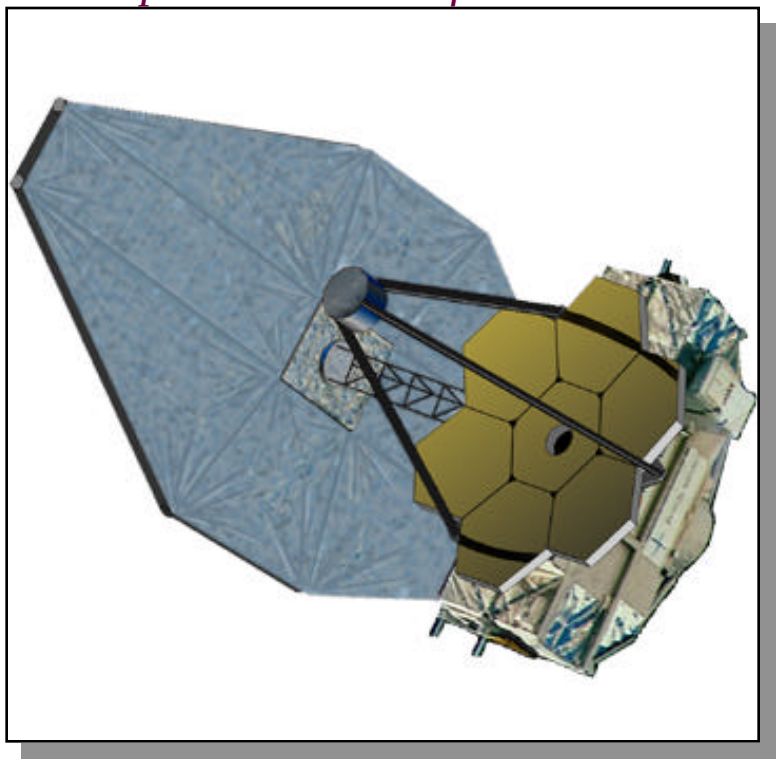
STATUS: DLR/DSS currently has a $4M budget shortfall, and the ASTROSPAS carrier availability in question

DoD Has Committed to Partnering with NGST in Technology Development and Pathfinder 3



$15M National Advanced Mirror System (AMSD) Program in FY 99-00

Ultra-lightweight, Deployable Active Optics Flight Experiment – Pathfinder 3

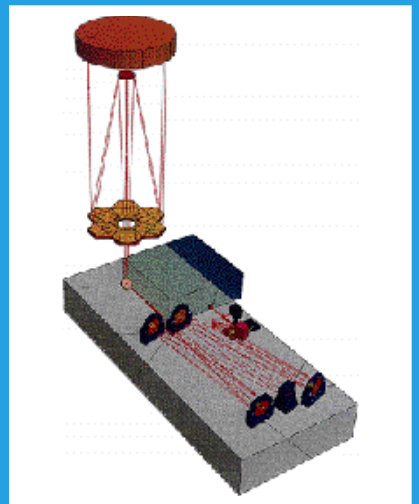


Technology Development Flow

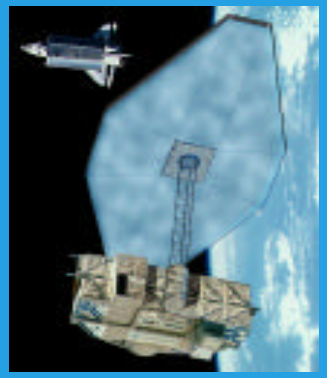
Ultra-Lightweight Active Mirror Technology

Components

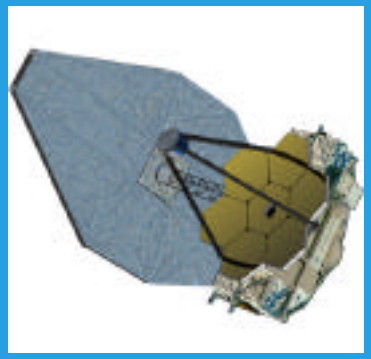
Ground Testbeds



Flight Demos

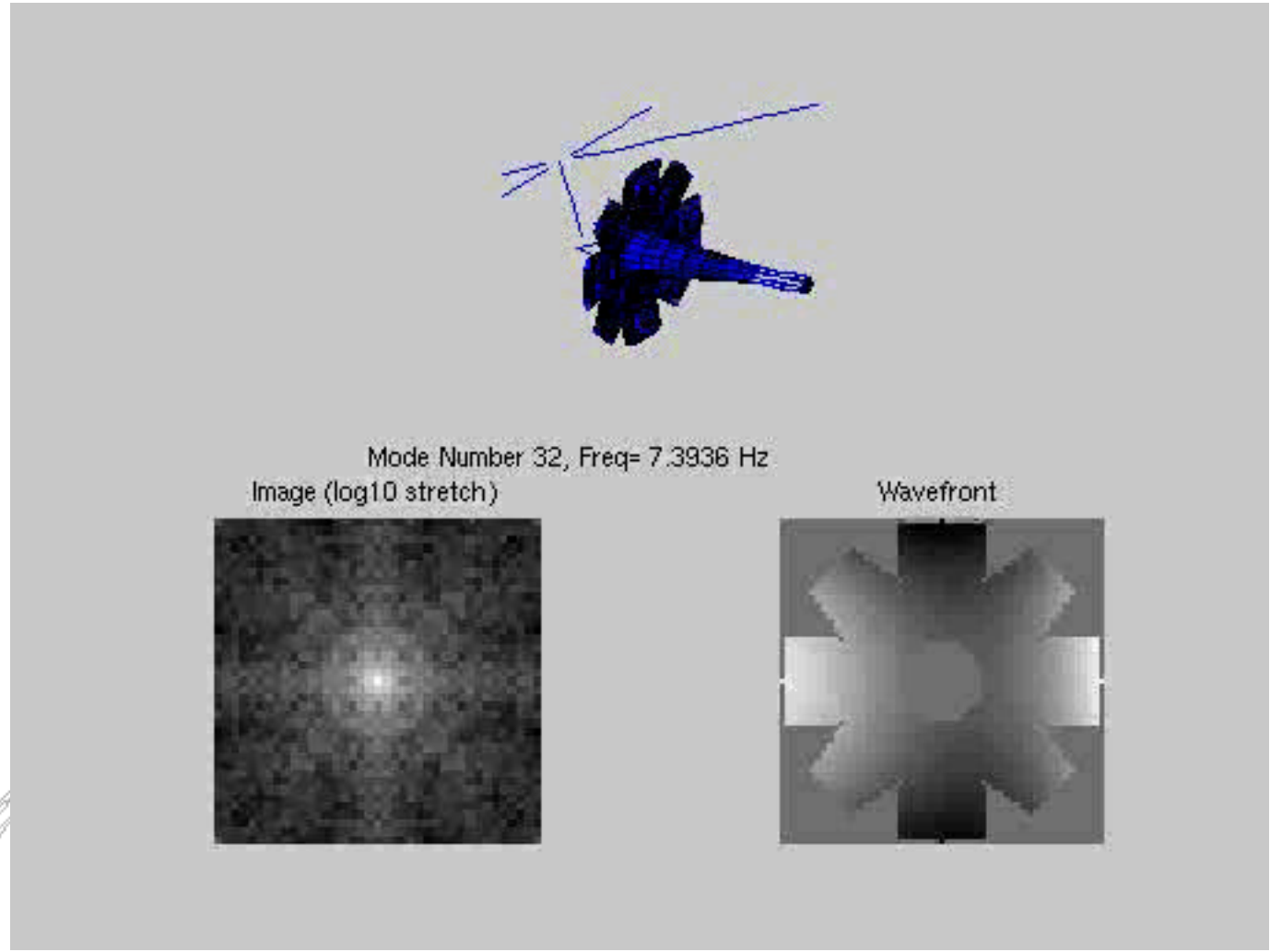


PF-1



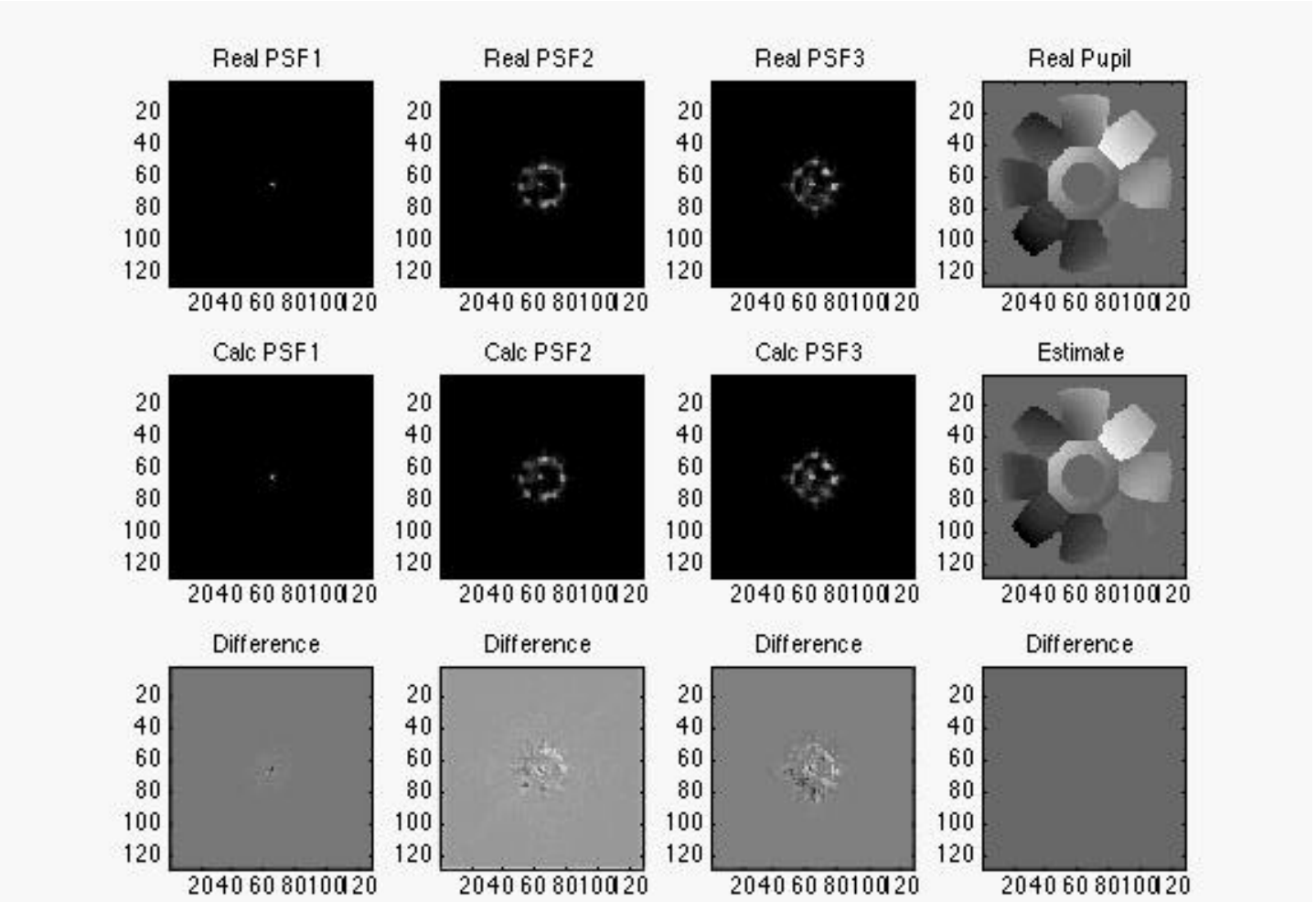
PF-3

Integrated Modeling



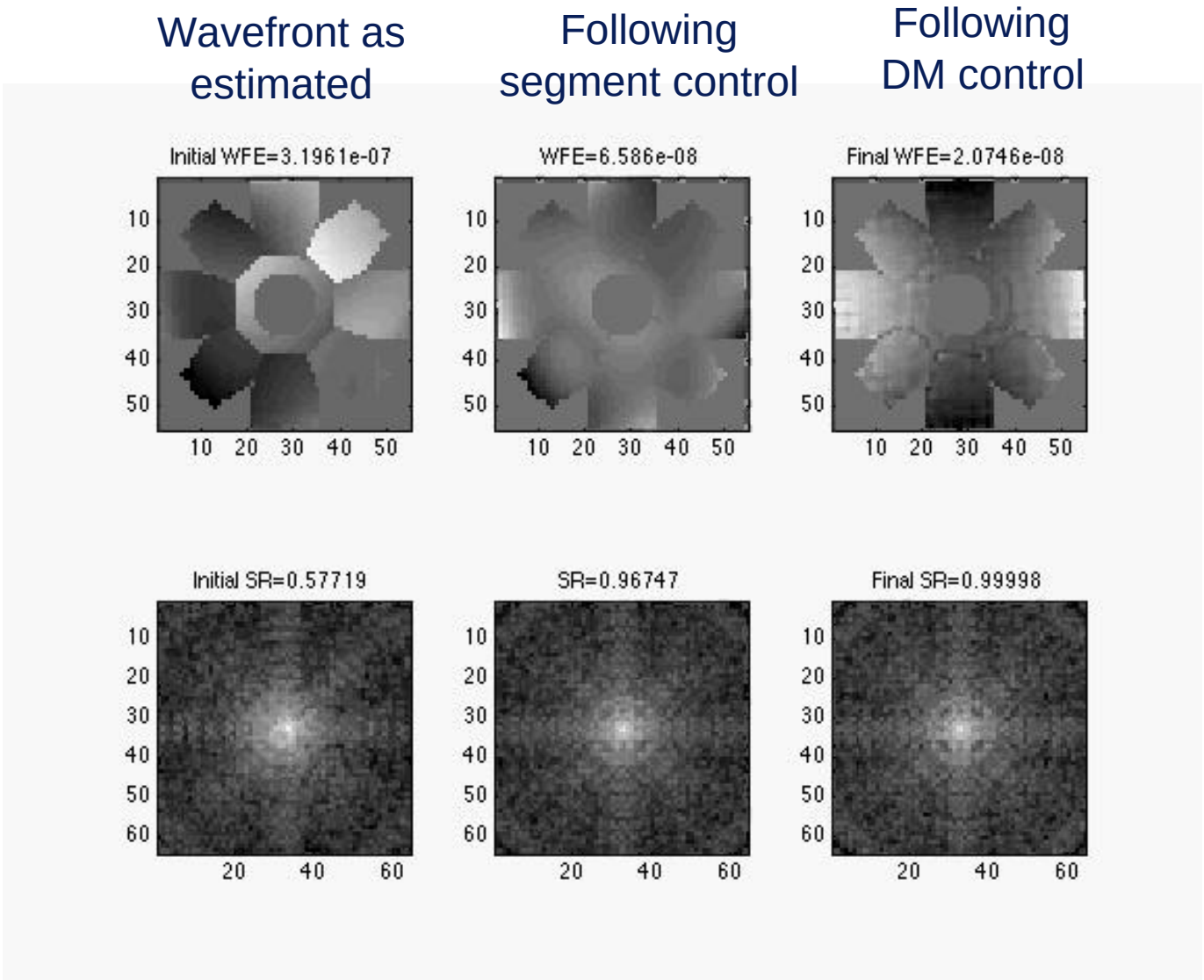
Integrated modeling allows investigation of structural characteristics on imaging performance

Fine Wavefront Sensing



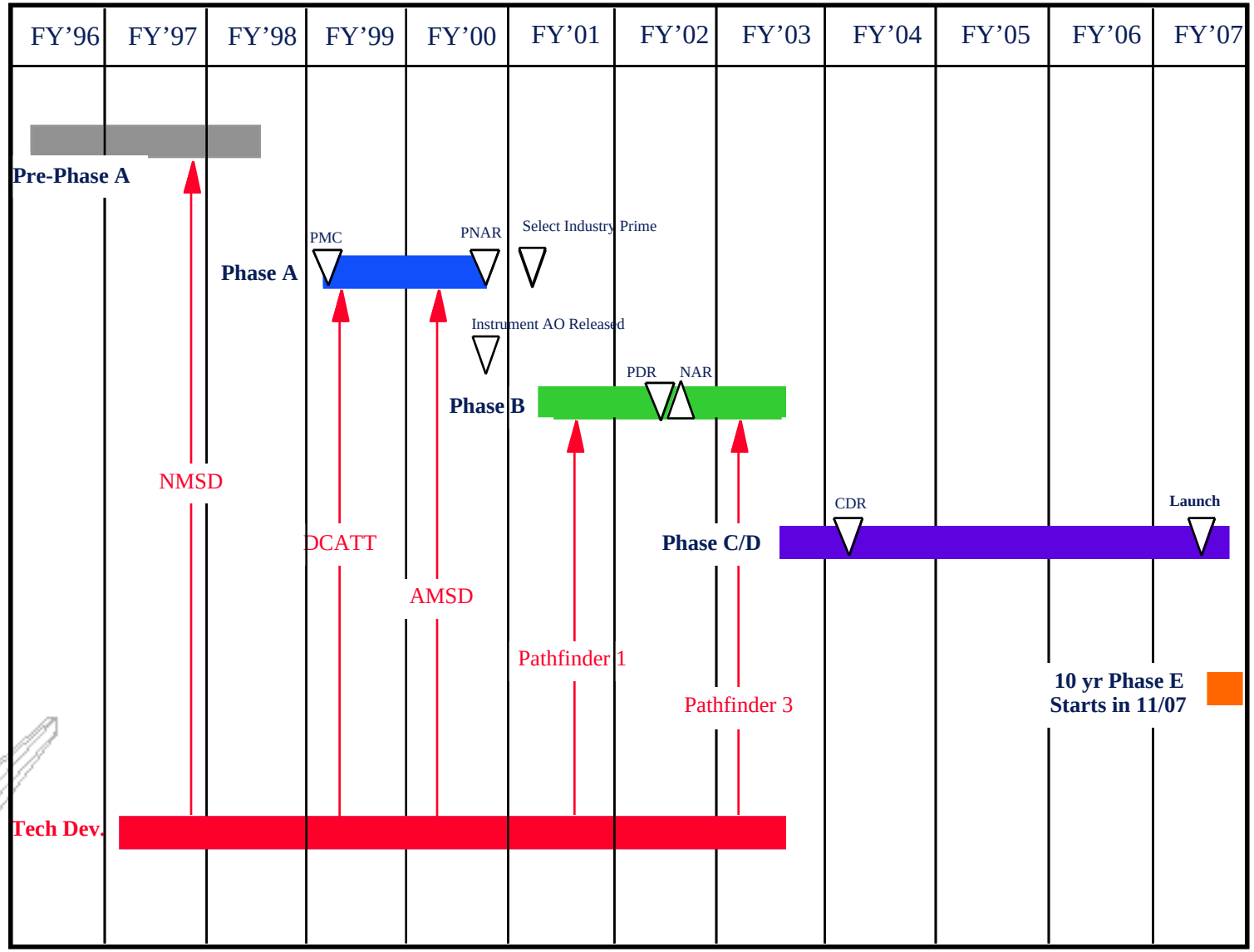
- Defocused images processed to determine pupil ("Real Pupil" not known)
- Wavefront estimated with high accuracy in this low-noise example

Fine Wavefront Control



- Retrieved wavefront used to compute optimal segment and DM control
- Final wavefront quality near perfect

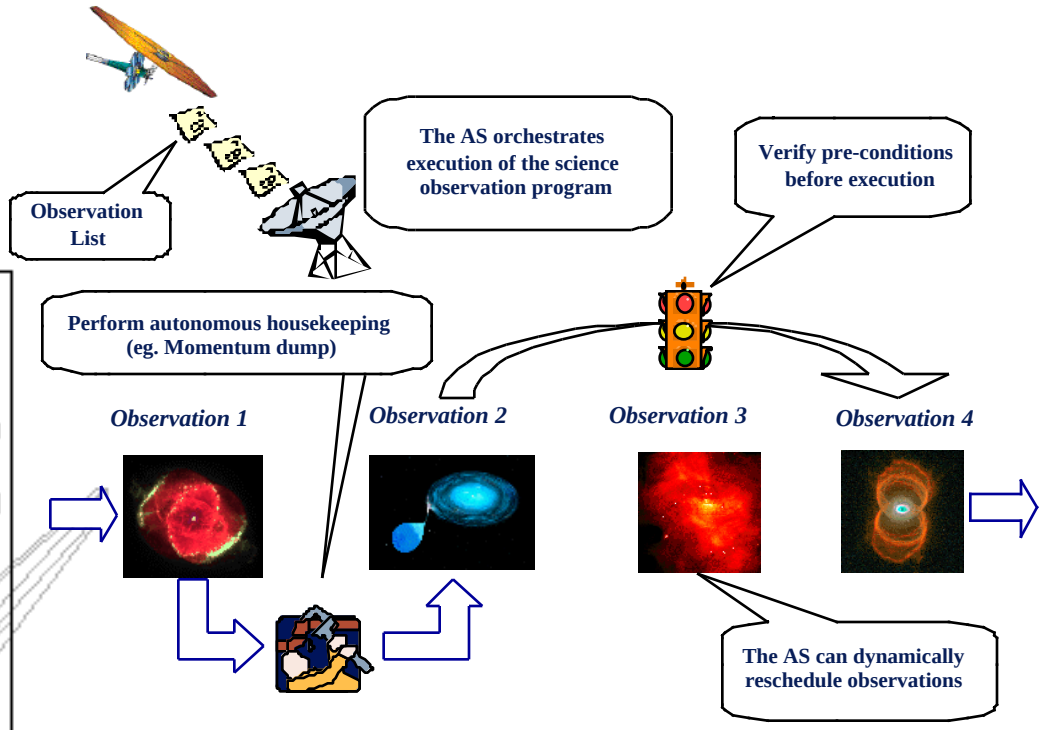
Top Level Schedule



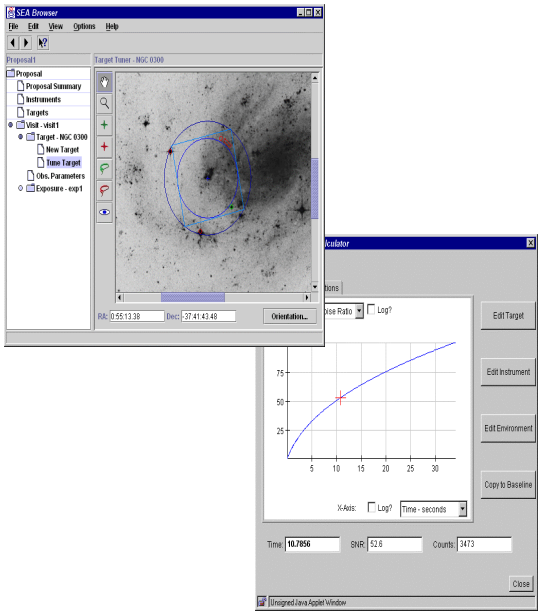
Science & Mission Operations Center

- ST ScI selected for NGST Science & Mission Operations Center
  - Ensures early involvement of scientists
- NGST and HST will be operating together over a 3-year period from 2007 - 2010

ST ScI



Adaptive Scheduler



Scientist Expert Assistant

Standing Review Board

Purpose

Provide the Project Office with programmatic and technical advice and guidance

Membership

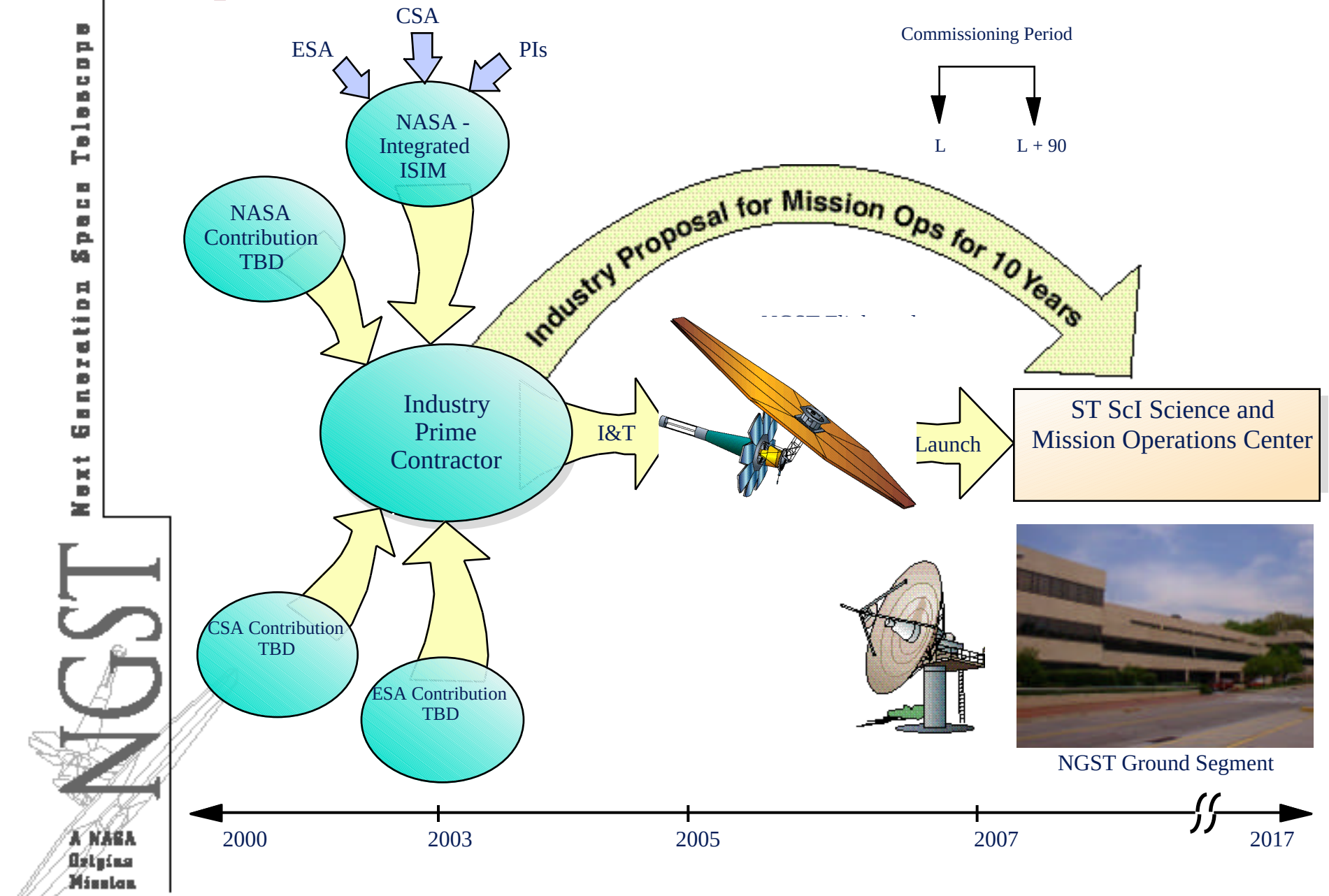
Chair - Dr. Dick Kurz, ESO Chief Engineer

Membership/Affiliation

Mr. Dick Dyer, Schaefer Optics consultant to DoD.
Dr. Richard Freeman, GSFC Chief Engineer
Mr. Kevin Hartnett, GSFC Ground Systems
Mr. John Casani, JPL Chief Engineer
Ms. Madeleine Marshall, Interface & Control Systems
Mr. Jean Olivier, MSFC Program Mgt. Division
Dr. Robert O'Donnell, MRJ Consultant to DoD
Dr. Robert Laskin, JPL SIM Project Technologist
Dr. Michael Hauser, ST ScI Deputy Director
Mr. Michel Verdant, ESA/ESTEC
Mr. V.K. Viswanathan, LANL Optical Designer, retired
Mr. Dennis McCarthy, JHU FUSE Project Manager
Dr. Chris Stevens, JPL Space Instruments Section
Mr. John Mangus, GSFC Optics, retired
Mr. Bob Shannon, UofA, Optical Sciences Center, retired
Mr. Rick Howard, Origins Program Executive
Dr Wayne Van Citters, NSF Program Manager

January 1998 meeting

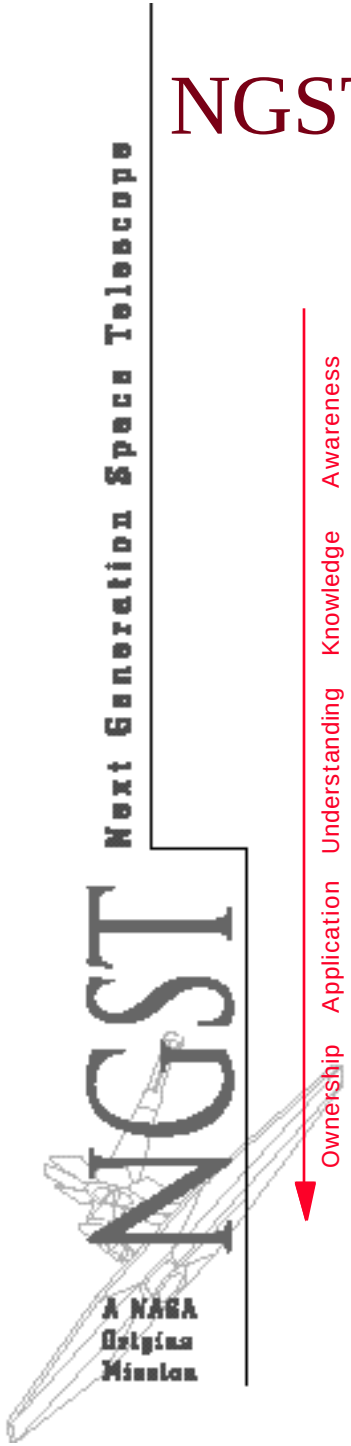
Acquisition Strawman

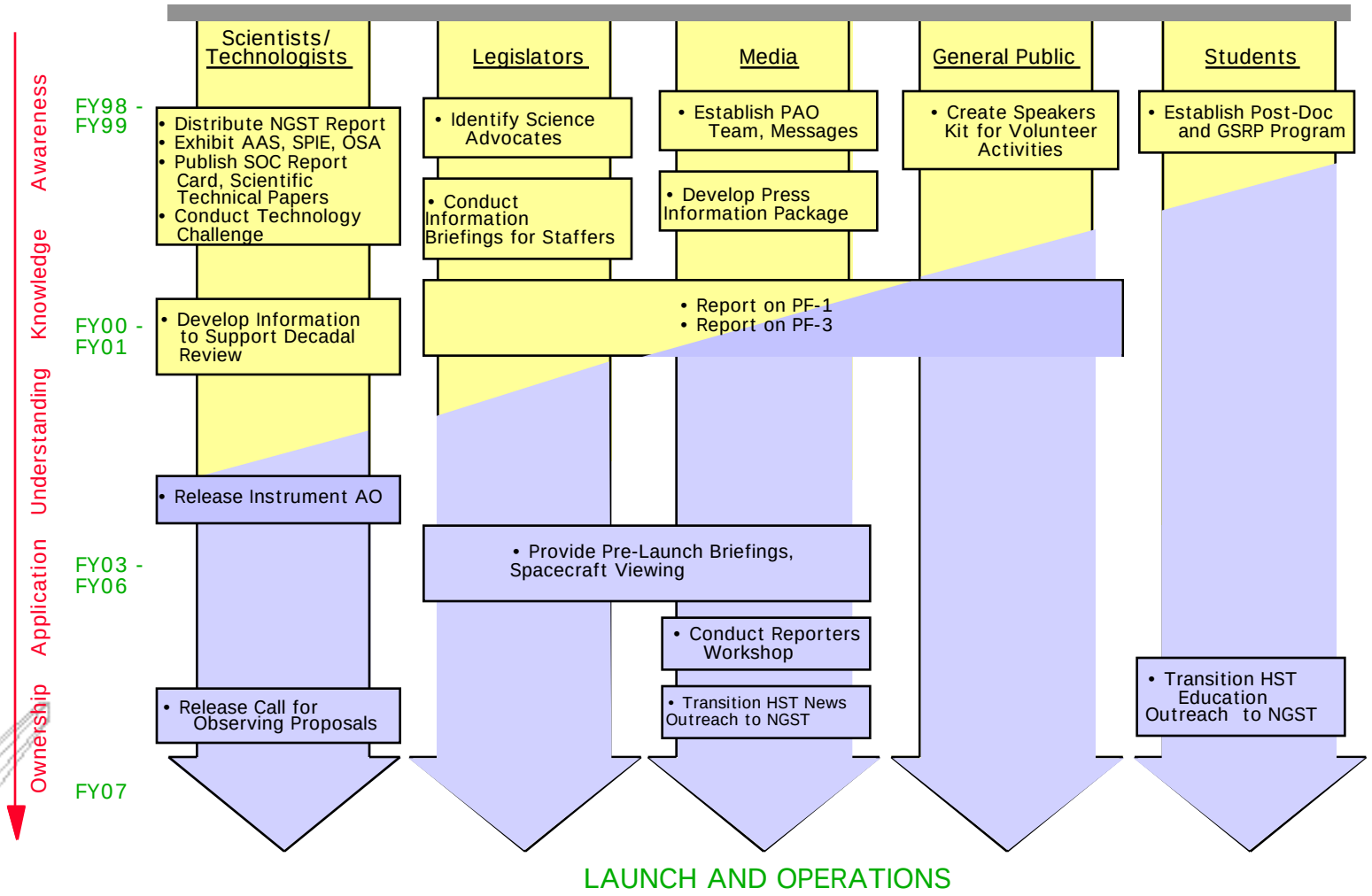


The Next Year on NGST

- ***Technology Development Milestones***
  - 2m Active Optics Segment Prototype
  - DCATT ‘First Light’
  - Cryogenic Actuator Lash Up
  - Technology Readiness Monograph
  - Joint NASA/DoD Advanced Mirror RFP
- ***Architecture Studies***
  - Completion of Pre A Studies
  - Competitive Selection of Industry Formulation Phase Partners
  - Documented Yardstick Concept Analyses
  - Cost Break Points Identified in Wavelength Coverage
  - First Correlation of Predicted Optical Control Algorithm Performance with DCATT Testbed Results

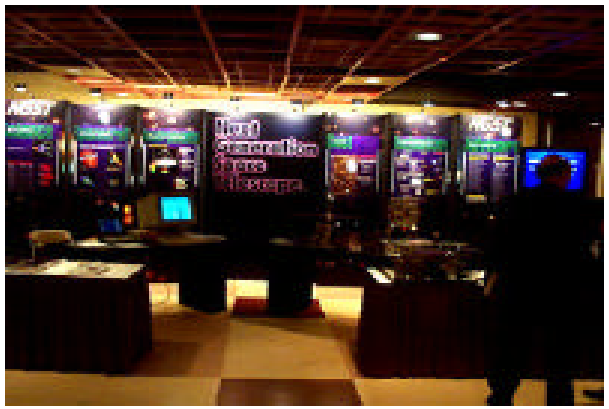
NGST Outreach Plan





Science & Technical Outreach

- ***Instruments***
  - Awards for the $750K NRA for Innovative Instrumentation Concepts Imminent
  - Proposals in evaluation for the NGST detector procurement
- ***Students***
  - NRC/RRA science and engineering fellowships in astronomy and adaptive optics
  - Graduate Student Research Program (GSRP) support for 1-2 students
- ***Technologists***
  - 2nd Annual Technology Challenge Review-West, June 3-5 in Oxnard, CA
- ***Science Community***
  - "Science with the NGST" 2nd Annual Science Symposium, hosted by ESA, in Liège, Belgium, June 15-18



Summary Of Accomplishments

- ***Architecture Studies***
  - NASA (yardstick) reference concept analyses complete
  - Pre A industry studies at the half-way point
  - Four^{+} viable observatory concepts
- ***Science***
  - Proceedings of "Science with NGST" published by Astronomical Society of the Pacific
  - Twelve US scientists competitively selected for the Ad Hoc Science Working Group (ASWG); to be augmented by 2 additional European scientists
  - Project scientist, John Mather, elected to the National Academy of Sciences
- ***Technology***
  - Developmental Cryogenic Active Telescope Testbed (DCATT) designed and peer-reviewed
  - NMSD mirror prototype at the CDR level
  - Industry deployment and detector testbeds under development

Project Manager's Perspective

Scientifically…

- ASWG members are fully engaged and working the DRM
- ESA astronomers very supportive of NGST and in process of responding to the first of ESA/ESTEC's RFPs
- CSA has expressed strong interest in partnering on NGST

Technologically…

- Competitively-selected technology contracts in full swing
  - –Detectors
  - –Actuators
  - –Mirrors
  - –SBIRs/STTRs
- Our three U.S. industrial partners are co-investing heavily in NGST for this early Phase of the program
- The areal density goal of 15 kg/m^2 for the NGST primary mirror is a challenging but worthwhile goal
  - –Optics community must come up with innovative ideas for demonstrating cost scalability, including reducing manufacturing schedule (cost)

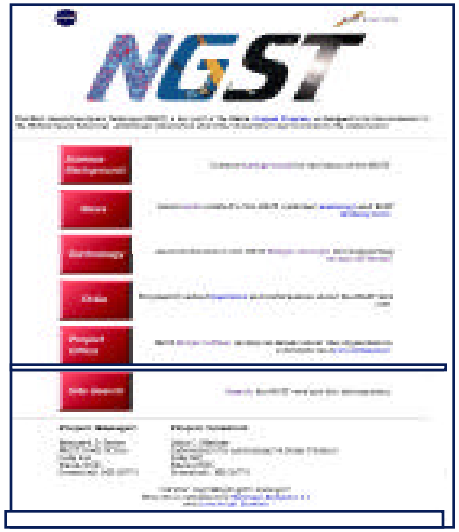
Programatically…

- Project conducting acquisition approach trade studies involving the definition of science instrument module interfaces

AA Take-Away

- *NGST will address a fundamental cosmological question, one which can only be answered once in human history*
  - How did stars, galaxies, and the large scale structure of our universe form?
- NGST as a powerful new observational tool will be:
  - A worthy successor to HST and SIRTF
  - Capable of seeing the dark universe light up with stars
  - Technologically as captivating in 2007 as Mars Pathfinder was in 1997
  - Affordable to the public

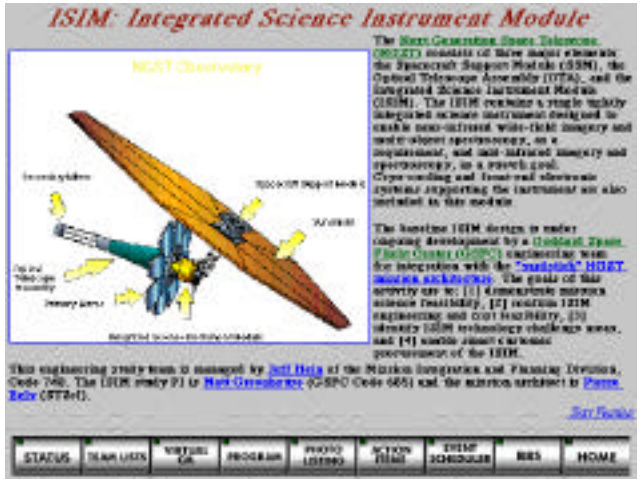
Web-Based Project Information



http://ngst.gsfc.nasa.gov

http://bretagne.gsfc.nasa.gov/

http://astro.estec.esa.nl/NGST/



http://www701.gsfc.nasa.gov/isim isim.htm

Next Generation Space Telescope
NGST
A NASA Origins Mission